TPC electronics Intro 2

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What are we going to build in the end?

- Radial position: 30-85cm (Cage instrumented down to 20cm)
- Number of readout channels: ~200K
- ~40KV in the middle (400V/cm)
- Chevron type readout pads with approximately 1x10 mm^2 area each

- c.f. ALICE
  - Radial position: 85cm-2.5m
  - Longitudinal volume: 2*2.5m
  - Drift voltage: 100KV (400V/cm)
  - Electronics: 560K channels

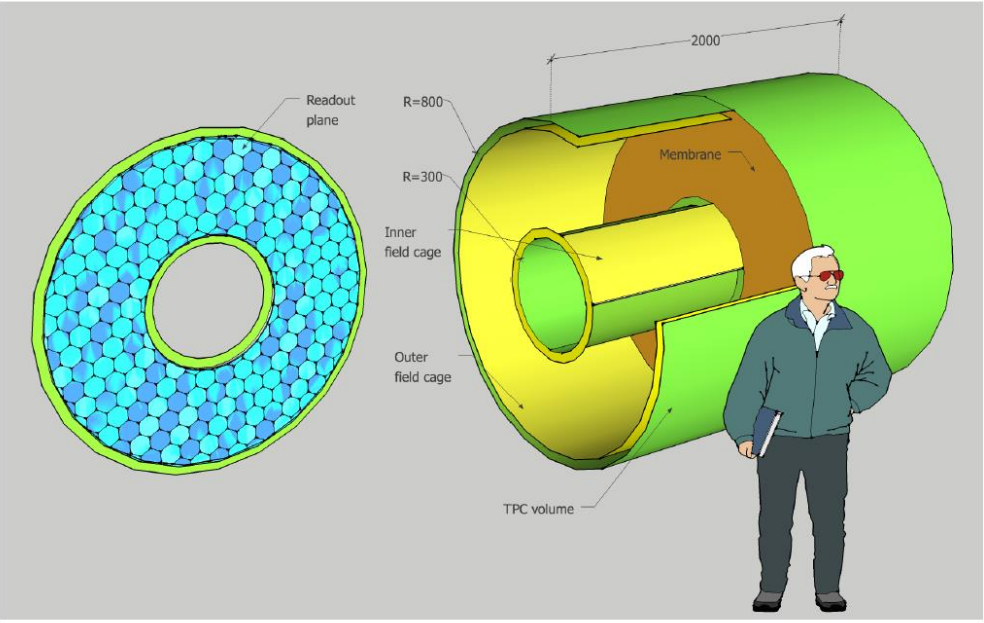


Figure 4.26: Schematic layout of TPC main elements.

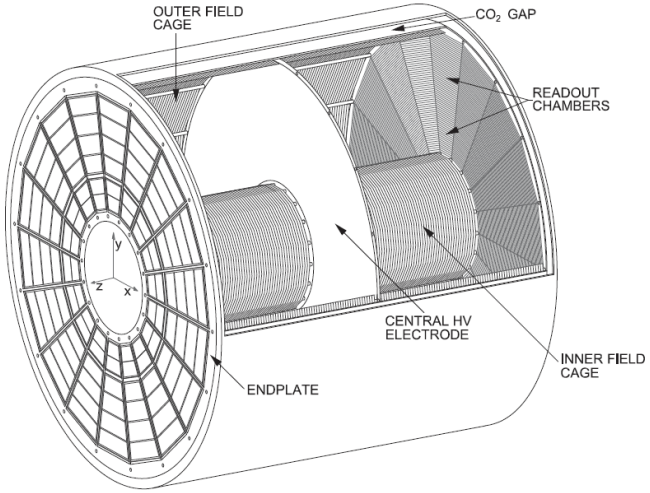


Figure 2.1: Schematic view of the ALICE TPC.

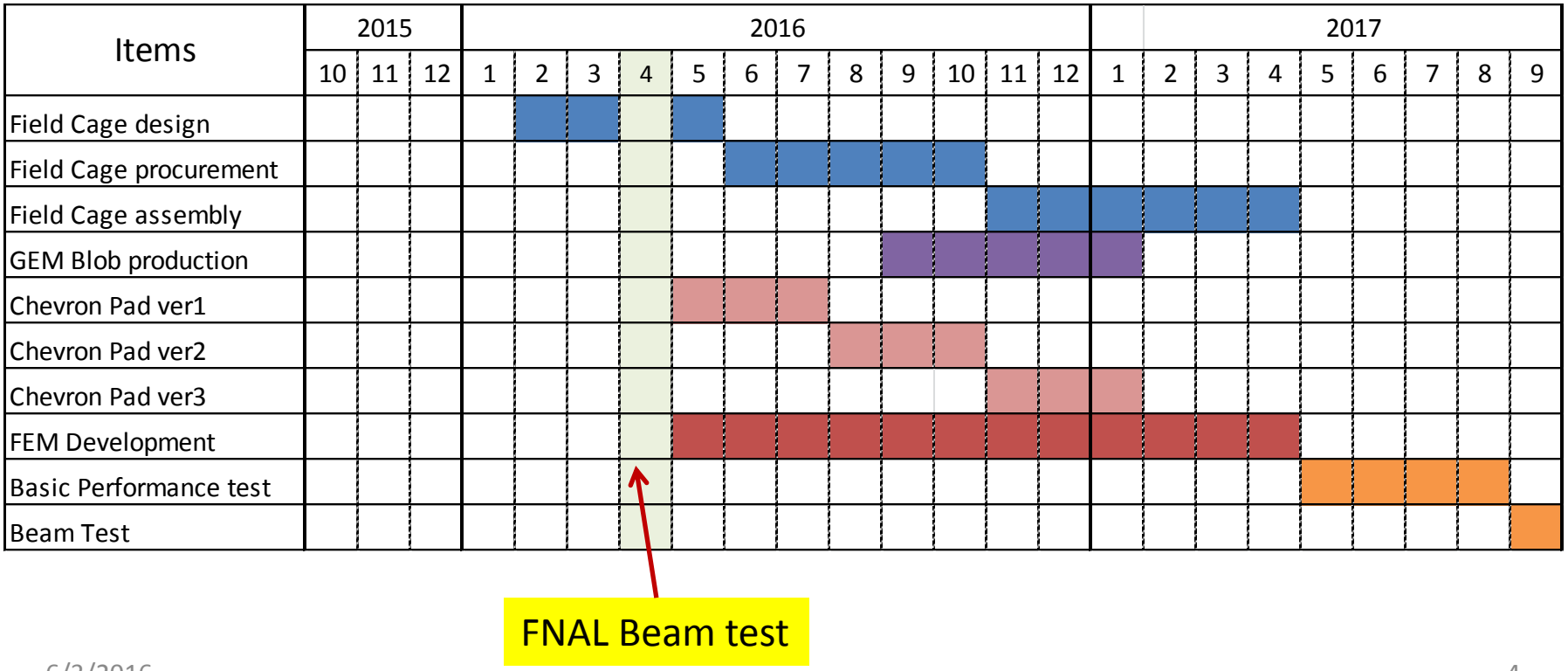
Fund

- TPC development is now funded by BNL LDRD
  - Two year funding with ~$150K/year. Considering contingency, it is effectively $100K/year
- Already significantly used for field cage development, etc.
- We have some fund left for electronics development
  - Also, we can consider applying another fund.

Readout situation

- We need electronics to readout. Based on the schedule outlined below, the electronics should be ready by the end of April next year
  - Roughly, one year from now

- We may want to establish a readout scheme that is also good for the final version if possible



We are now for STAR iTPC electronics

- Follow the current STAR's iTPC electronics development plan
- Schedule of SAMPA chips
  - The first non-packaged SAMPA chip should come out early June
  - A prototype testing board for the non-packaged chips is designed and will be manufactured by ALICE-affiliated French group by July.
    - Tonko will get one board for local STAR preliminary tests.
  - The packaged chip is expected in mid/late July at which point STAR will have their own board for further testing and other integration
- No formal design of the electronics exists at this moment
  - Cost estimate for 80K channels in the following slide.

SAMPA chip in detail

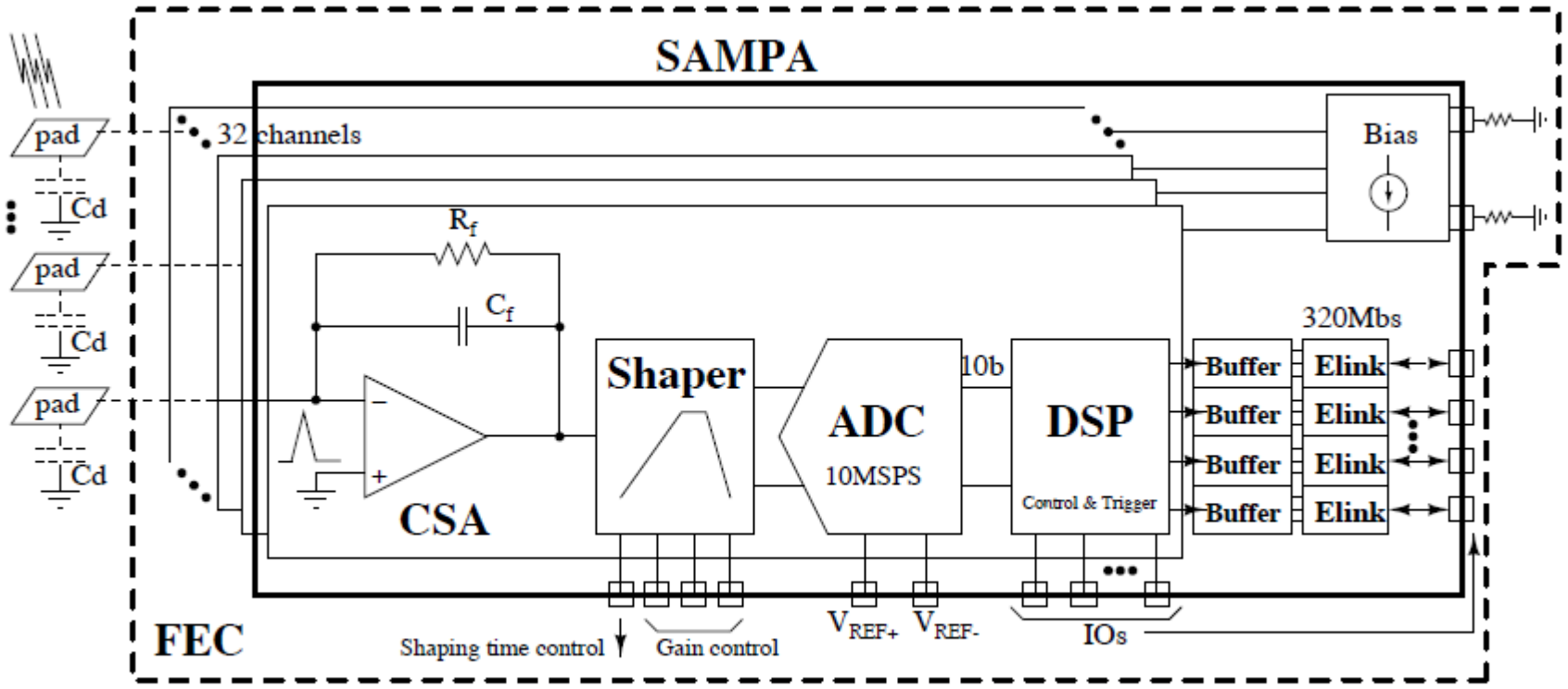
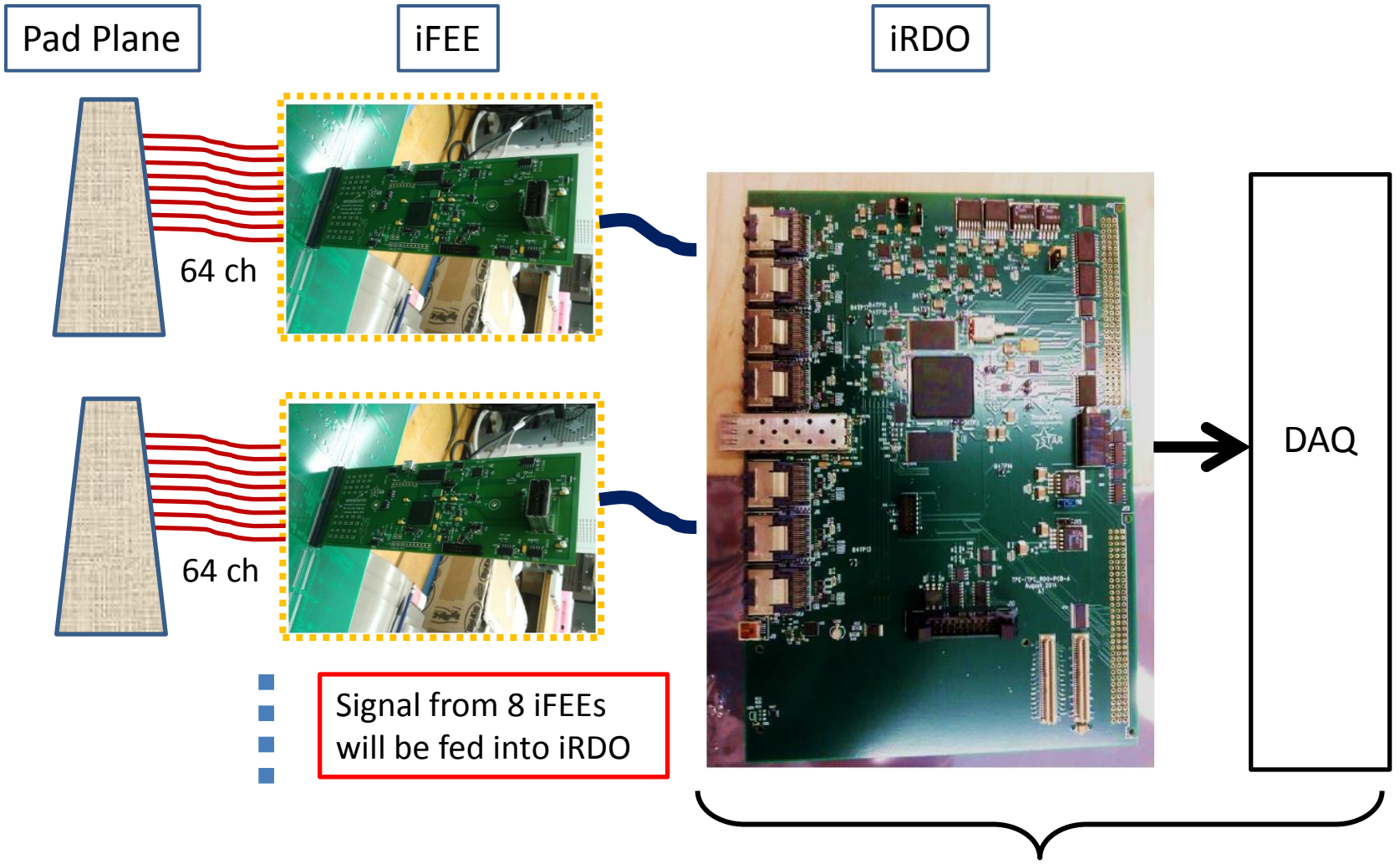


Figure 6.4: Schematic of the SAMPA ASIC for the GEM TPC readout, showing the main building blocks.

Readout scheme



Ref: Readout for ALICE TPC upgrade

- CRU interfaces the FEC and online computer farm
  - Our case, DCM-II will play the role of this.
  - FEC will send data in non-triggered mode, while DCM-II will send data in triggered mode
  - We may have to make a separate data collection stream for the TPC

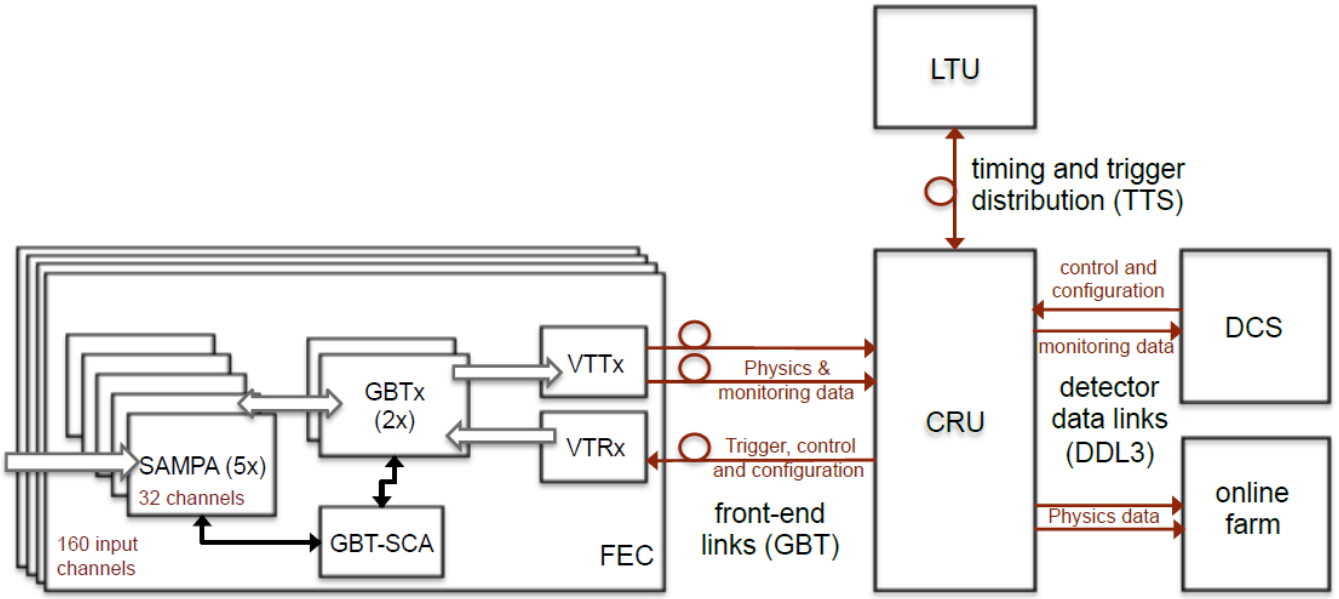


Figure 6.9: Schematic of the TPC readout system with the CRU as central part interfacing the front-end electronics to the trigger system, the DCS and the online farm.

Data rate consideration

- ALICE case (based on TDR):
  - Average event size: 20Mbyte/s (dN/dy=8000 for most central)
    - This number is no-pile up with shaping, sampling and zero-suppression
  - Number of pads: 560K
  - Interaction rate: 50KHz
  - Data rate: 50KHz*20Mbytes/s = 1Tbytes/s

- sPHENIX case:
  - Average event size: 7.5Mbytes/s (dN/dy=3000 for most central)
  - Number of pads: 200K
  - Interaction rate: 25KHz
  - Data rate: 25KHz*7.5Mbytes/s * 0.4 (scale by number of pads) = ~75Gbytes/s

From Tonko's slides (for 80K channels)

We have to figure out the cost for labor!

Presented in Jan, 2016

Cost

	# items	# with spares	$ per item	$ all	With contingency (20%), overhead (56%)
SAMPA	2640	3500	$44	$154k	
iFEE	1320	1580	$130 (wo SAMPA)	$206k	
iRDO	96	116	$1300	$151k	
DAQ Receiver	24	26	$3500	$91k	
Cables, fibers, misc	-	-	-	$50k	
Power Supplies	48	52	$600	$32k	
DAQ PC	24	26	$3000	$80k	
Totals				**$764k**	**$1430k**

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From Tonko's slides

We could use the prototype iFEE for the current TPC development under BNL LDRD

Presented in Jan, 2016

Schedule

	2016	2017	2018 early	2018 late
padplane	prototype test produce		start sector installation	end sector installation
iFEE	evaluate SAMPA prototype with SAMPA	final version produce 1 sector's worth	produce all PCBs vet PCB purchase all components install into 1 sector & test	SAMPA arrives mount SAMPA & components Q&A install all full system test
iRDO	prototype 2	final version produce 1 sector's worth	produce & Q&A all install into 1 sector & test	install all full system test
Power Supplies Trigger Cables Fibers	evaluate	evaluate test	purchase & install all full test using 1 sector's worth	full system test
Receiver Cards	prototype test	final version	purchase & install all full test using 1 sector's worth	full system test
DAQ PCs	develop drivers	final drivers & software... specification	purchase & install all full test using 1 sector's worth	full system test

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Backup

sPHENIX TPC FEC cost (Nov. 2015)

Test Stand Modification	30	$8,000.00	TPC-E-2180
Assemble and test prototype electronics: preproduction prototype	20	$3,000.00	TPC-E-2230
Review and write design change specifications	25	$43,000.00	TPC-E-2260

BOE prepared

1.3.4.10.1.3

Items	Duration (d)	costs	Notes
Final external design review	20	$33,000.00	TPC-E-3120
Procure all components needed for TPC FEC production	20	$750,000.00	TPC-E-1180, labor not included
purchase a power supply module	5	$84,000.00	Just to order, labor not included
Fabricate and assemble TPC FEC: production	55	$220,000.00	TPC-E-2180
Test and qualify TPC FEC production	55	$40,000.00	TPC-E-1230

Not listed in the WBS

Items	Duration (d)	costs	Notes
Shipping fee (to ORNL)	10	$600.00	TPC-E-1190
Proess University of Houston Subcontract fee	1	$6,900.00	TPC-E-1180
Final Vendor Evaluation and Selection	70	$22,000.00	TPC-E-3110
FY16, Mgmt coord, contributed LOE and Travel	270	$49,000.00	TPC-TR-FY16
FY17, Mgmt coord, contributed LOE and Travel	250	$42,000.00	TPC-TR-FY17
FY18, Mgmt coord, contributed LOE and Travel	200	$43,000.00	TPC-TR-FY18

Total

Total Time (days, listed in WBS)	750	*Not accounting for any parallel job splitting
Total Costs	$1,869,500.00	
Additional Costs for labor	$561,600.00	* used 8hrs/day, $120/hr * labor days: 750 - 165 (parts procurement and fabrication) = 585 days * maybe double counting the labor cost for design/layout (correspoding to $270,000.00)

*** The number in notes are the pointer to the ALICE TPC electronics WBS

*** For actual material costs related to fabrication of boards, I scaled the costs by the factor of 2.5; We assume 200K channels, while ALICE TPC upgrade, it is 550K channels. 550/200=2.75, so 2.5 is a conservative estimate of the cost of fabrication

Almost complete copy of ALICE WBS scaled by the # channels (560K -> 200K)

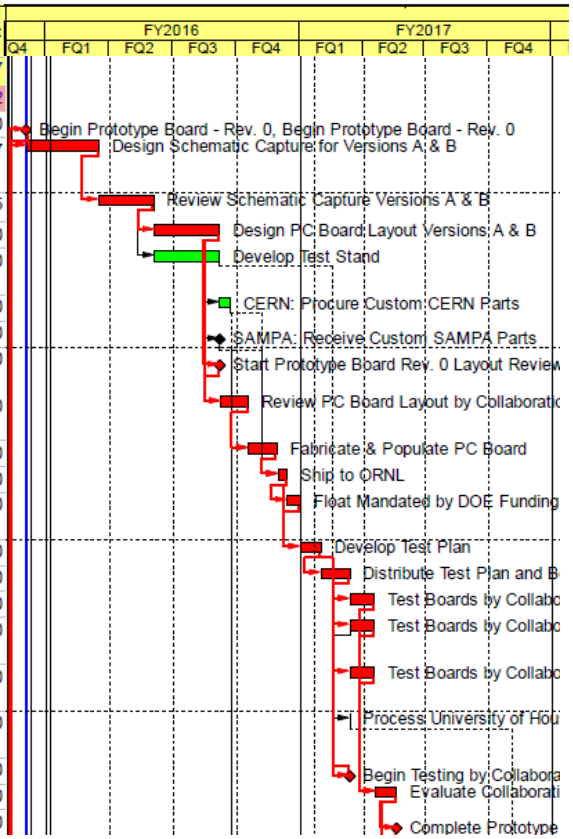
Cost and Schedule consideration

- Based on ALICE upgrade TPC electronics WBS
  - Details are in ORNL's WBS in the backup
- ALICE case: Two prototypes: Rev0 and Rev1
  - Takes three years to complete
  - Basically, board design and layout
- sPHENIX case: prototype-1 and pre-production prototype
  - Should take three years or less to complete
  - Pre-production prototype can be used for performance evaluation of TPC detector itself
- Cost partly depends on the number of channels
  - Material cost for the final production is reduced proportionally by the number of channels compare to ALICE TPC case
  - Detail evaluation of labor and material costs ended up with ~$2.5M for the sPHENIX case
  - Details follow from the next slide

ALICE schedule from WBS last year

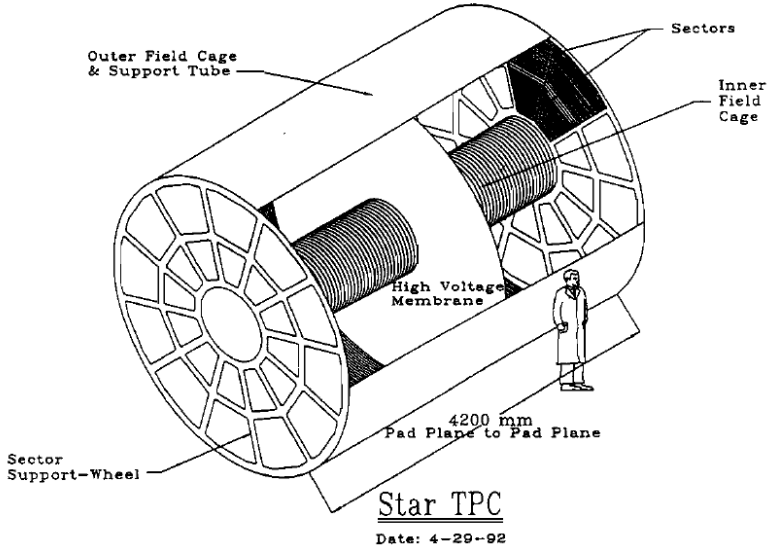
- The very first version of proto-type will be produced by the end of FY16
  - I thought they will produce ~10% of total. I should check
- One option is to join the test board effort?

Activity ID	Activity Name	Rem Dur	Start	Finish	Total Float	Budgeted Total Cost
ALICE 1.1.2	Electronics	742d	01-Oct-2015	28-Sep-2018	0d	$3,158,369.87
ALICE 1.1.2.1	Prototype Board - Rev. 0	360d	01-Oct-2015	20-Mar-2017	0d	$480,100.52
TPC-E-Mi10	Begin Prototype Board - Rev. 0	0d	01-Oct-2015		0d	$0.00
TPC-E-1110	Design Schematic Capture for Versions A & B	66d	02-Oct-2015	13-Jan-2016	0d	$121,153.47
TPC-E-1120	Review Schematic Capture Versions A	55d	14-Jan-2016	01-Apr-2016	0d	$100,718.45
TPC-E-1130	Design PC Board Layout Versions A & B	66d	04-Apr-2016	06-Jul-2016	0d	$56,743.00
TPC-E-1140	Develop Test Stand	66d	04-Apr-2016	06-Jul-2016	124d	$122,203.60
TPC-E-1160	CERN: Procure Custom CERN Parts	12d	07-Jul-2016	22-Jul-2016	17d	$6,180.00
TPC-E-Mi12	SAMPA: Receive Custom SAMPA Parts	0d	07-Jul-2016		29d	$0.00
TPC-E-Mi15	Start Prototype Board Rev. 0 Layout Review by Collaboration	0d	07-Jul-2016		0d	$0.00
TPC-E-1150	Review PC Board Layout by Collaboration	28d	08-Jul-2016	16-Aug-2016	0d	$0.00
TPC-E-1180	Fabricate & Populate PC Board	30d	17-Aug-2016	28-Sep-2016	0d	$20,660.00
TPC-E-1190	Ship to ORNL	10d	29-Sep-2016	12-Oct-2016	0d	$530.00
TPC-E-1185	Float Mandated by DOE Funding Profile Gap	13d	13-Oct-2016	31-Oct-2016	0d	$0.00
TPC-E-1200	Develop Test Plan	20d	01-Nov-2016	30-Nov-2016	0d	$18,502.80
TPC-E-1210	Distribute Test Plan and Boards to Coll	22d	01-Dec-2016	10-Jan-2017	0d	$2,120.00
TPC-E-1220	Test Boards by Collaborator ORNL / UT	26d	11-Jan-2017	16-Feb-2017	0d	$0.00
TPC-E-1230	Test Boards by Collaborator University of Houston	26d	11-Jan-2017	16-Feb-2017	0d	$3,837.60
TPC-E-1250	Test Boards by Collaborator - University of Bergen	26d	11-Jan-2017	16-Feb-2017	0d	$0.00
TPC-E-1260	Process University of Houston Subcontract Fee	1d	11-Jan-2017	11-Jan-2017	25d	$6,890.00
TPC-E-Mi17	Begin Testing by Collaborators	0d	11-Jan-2017		0d	$0.00
TPC-E-1270	Evaluate Collaboration Feedback	22d	17-Feb-2017	20-Mar-2017	0d	$20,561.60
TPC-E-Mi19	Complete Prototype Board - Rev. 0 (RR)	0d		20-Mar-2017	0d	$0.00



How sPHENIX TPC is compared with others?

- STAR
  - Radial position: 60cm-1.9m
  - Longitudinal volume: 2*2.1m
  - Drift voltage: 28kV (135V/cm)
  - Electronics: 140K channels
  - dN/dy: 3000
- ALICE
  - Radial position: 85cm-2.5m
  - Longitudinal volume: 2*2.5m
  - Drift voltage: 100KV (400V/cm)
  - Electronics: 560K channels
  - dN/dy: 8000 (40% occupancy at the inner radius)



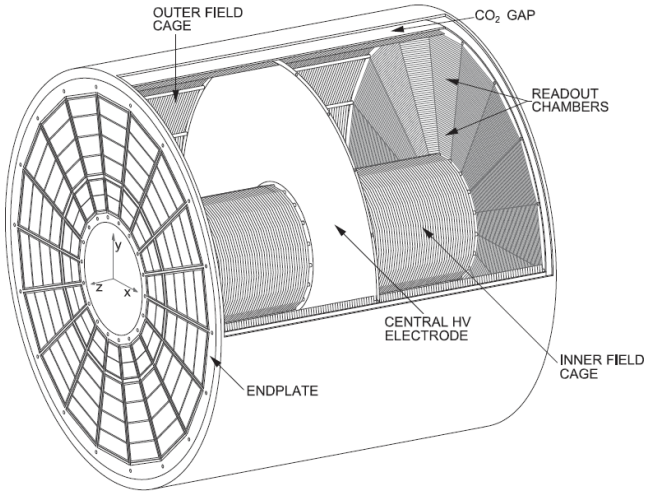


Figure 2.1: Schematic view of the ALICE TPC.

sPHENIX TPC is around half scale downsize of these TPCs!